uFR serial - Communication protocol for uFR series devices

uFR Series devices can establish communication over FTDI's Virtual COM port, so devices are seen as standard COM port hardware.
Communication parameters are :

Readers with FTDI serial interface:

uFR Classic and uFR Advance readers with USB connection:
Serial communication: 1 Mbps, 8-N-1, Flow control: None;

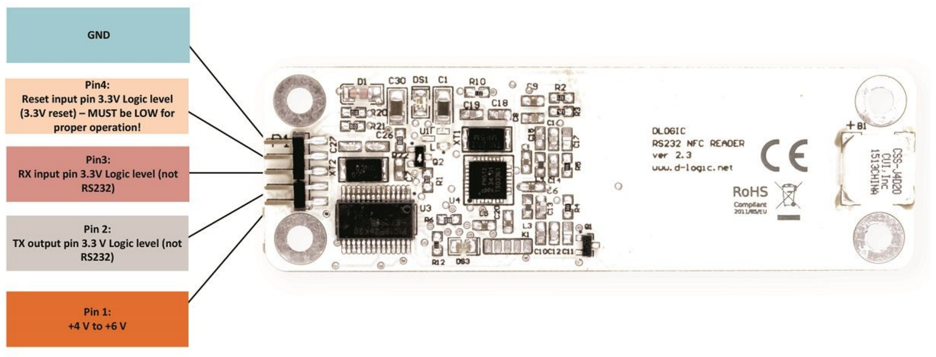
uFR BaseHD readers with “uFR support” firmware installed (ex. XR and uFR XRc readers):
Serial communication (using VCOM FTDI driver): 250 kbps, 8-N-1, Flow control: None;

Readers without FTDI serial interface:

RS485 (connection without USB/RS-485 converter): variable baudrate can be set through software tool. Current baud rate must be known when changing baudrate. Default baudrate is 250 kbps.

uFR Classic Nano and Card Size:
UART / TTL: 115200 bps, 8-N-1, Flow control: None

Pinout for UART / TTL model is presented below:


GND
Pin4: Reset input pin 3.3V Logic level (3.3V reset) – MUST be LOW for proper operation!
Pin3: RX input pin 3.3V Logic level (not RS232)
Pin 2: TX output pin 3.3 V Logic level (not RS232)
Pin 1: +4 V to +6 V
DLOGIC RS232 NFC READER ver 2.3 www.d-logic.net

uFR Series Nano RS232 model pinout

For communication purposes between reader devices and host PC, D-Logic's proprietary protocol called “uFR serial” is created.

All communication is initiated by the host (PC or other platform) to which the device is connected.

Maximum data transferred by single command or received by one device response, from firmware version 3.9.44 is 256 bytes, and before is 192 bytes.

Generally, there are two types of packets:

CMD – command sent by host to device
ANS – answer sent from device to host

CMD can be short or long set. CMD short set is always 7 byte long while CMD long set – called CMD_EXT can have variable length.

Answer have following types:

ACK – Acknowledgment, everything is OK, device is waiting for next CMD or CMD EXT
ERR – Error occurred, error byte defines ERR_TYPE
RSP – Response from device on CMD or CMD_EXT

Communication constants bytes defines type of packet, which can be seen in first three bytes of each packet.
First byte of each packet is HEADER byte. Second byte is always CMD_CODE. Third byte is TRAILER byte.

Table1. Communication constants			
CMD_HEADER	**0x55**	**CMD_TRAILER**	**0xAA**
ACK_HEADER	**0xAC**	**ACK_TRAILER**	**0xCA**
RESPONSE_HEADER	**0xDE**	**RESPONSE_TRAILER**	**0xED**
ERR_HEADER	**0xEC**	**ERR_TRAILER**	**0xCE**

CHECKSUM

All checksums in this document are calculated in the same manner: row of bytes is used for checksum calculation, each byte is XOR-ed with next one until the end of row. Final value is incremented with 0x07.
For example, CMD packet has 7 bytes, where 7th byte is checksum of previous 6 bytes:

CHECKSUM = (Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6) + 0x07

CMD codes

Each command has its corresponding value - look at COMMANDS OVERVIEW.

Error codes

If error occurs, device will answer with ERR packet. Each Error has its corresponding value which can be found in table in Appendix: ERROR CODES.

CMD packet

CMD packet can be short – 7 byte long or EXT-ended with variable length. In case of EXT CMD packet, fourth byte of CMD packet is greater than 0, containing integer value – length of CMD_EXT packet. When issuing CMD_EXT, always main CMD 7-byte long packet goes first. If everything as expected, device will answer with ACK packet, waiting for CMD_EXT packet. On error, device will answer with ERR packet. CMD_EXT consists of various different parameters, depending on command type, so CMD_EXT does not have fixed length and order of parameters.

CMD packet has following structure:

Mandatory 7 byte CMD packet structure						
Byte 1	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
CMD_HEADER	**CMD_CODE**	**CMD_TRAILER**	**CMD_EXT_Length**	**CMD_Par0**	**CMD_Par1**	**CHECKSUM**

Byte 1: CMD_HEADER as defined in Table1.Communication constants, 0x55
Byte 2: CMD_CODE as defined in Table2. CMD_CODE values
Byte 3: CMD_TRAILER as defined in Table1.Communication constants, 0xAA
Byte 4: CMD_EXT_Length: If 0 than the “CMD EXT” is not used); ELSE value is length of whole CMD_EXT packet
Byte 5: CMD_Par0: command parameter0, takes different values depending on command
Byte 6: CMD_Par1: command parameter1, takes different values depending on command
Byte 7: CHECKSUM – Checksum of Bytes 1 to 6 as explained above

CMD_EXT packet has following structure:

CMD_EXT packet structure			
Byte 1	**..**	**Byte N**	**Byte N+1**
Parameter bytes 1 to N			**CMD_EXT_CHECKSUM**

Parameter bytes 1 to N – different parameters, values depends on type of command
CMD_EXT_CHECKSUM - Checksum of bytes 1 to N
CMD_EXT_Length is number of all bytes including CMD_EXT_CHECKSUM; e.g. length is N+1

ANSWER packet types

The device can answer with following packet types:

ACK – Acknowledgment packet

If command and CMD packet are properly configured (structure and checksum) and additional CMD_EXT packet needs to be sent, device will answer with ACK packet.

ERR – Error packet

If error occurred, device will answer with ERR packet. Some commands can return ERR_EXT set. In that case ERR_EXT packet comes immediately after ERR packet.

RSP – Response packet

If properly configured CMD or CMD_EXT packet is sent, device will answer with RSP or RSP_EXT packet, which depends on command issued. For examples, if CMD needs answer which is short enough for RSP packet, there will be no RSP_EXT packet. Otherwise, if CMD or CMD_EXT needs answer with more bytes, RSP_EXT will come immediately after RSP packet. Common situation is when reading data with LinearRead command, where device will answer with row of card data bytes.

ACK – Acknowledgment packet

ACK packet has following structure:

ACP packet structure						
Byte 1	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
ACK_HEADER	**CMD_CODE**	**CMD_TRAILER**	**Irrelevant, not used in ACK packet**			**CHECKSUM**

Byte 1: ACK_HEADER as defined in Table1.Communication constants, 0x55
Byte 2: CMD_CODE as defined in Table2. CMD_CODE values. Device ACK-nowledge that previous
command is properly sent
Byte 3: ACK_HEADER as defined in Table1.Communication constants, 0x55
Byte 4, Byte 5, Byte 6: Not used in ACK packet, values are 0x00

Byte 7: CHECKSUM – Checksum of Bytes 1 to 6 as explained above

ERR – error packet

ERR packet has following structure:

Mandatory 7 byte ERR						
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
ERR_HEADER	ERROR_CODE	ERR_TRAILER	ERR_EXT length	Err_Val0	Err_Val1	CHECKSUM

Byte 1: ERR_HEADER as defined in Table1.Communication constants, 0xEC
Byte 2: ERR_CODE as defined in Table3. ERROR CODES.
Byte 3: ERR_TRAILER as defined in Table1.Communication constants, 0xCE
Byte 4: If ERR_EXT exists, this byte contains length of ERR_EXT packet (including ERR_EXT checksum)
Byte 5: Possible additional info on error can be defined in ERR_Val0
Byte 6: Possible additional info on error can be defined in ERR_Val1
Byte 7: CHECKSUM – Checksum of Bytes 1 to 6 as explained above

ERR_EXT and has following structure:

ERR_EXT packet structure			
Byte 1	..	Byte N	Byte N+1
Error bytes 1 to N			ERR_EXT_CHECKSUM

Byte 1: First Byte of ERR_EXT
…
Byte N: N-nth Byte of ERR_EXT
Byte N+1: ERR_EXT_CHECKSUM, checksum of Bytes 1 to N, calculated as explained earlier.

RSP – response packet

RSP packet has following structure:

Mandatory 7 byte RSP						
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
RSP_HEADER	CMD_CODE	RSP_TRAILER	RSP_EXT length	RSP_Val0	RSP_Val1	CHECKSUM

Byte 1: RSP_HEADER as defined in Table1.Communication constants, 0xED
Byte 2: CMD_CODE as defined in Table2. CMD_CODE values

Byte 3: ERR_TRAILER as defined in Table1.Communication constants, 0xDE
Byte 4: If RSP_EXT exists, this byte contains length of RSP_EXT packet (including RSP_EXT checksum)
Byte 5: Possible additional info on RESPONSE can be defined in RSP_Val0
Byte 6: Possible additional info on RESPONSE can be defined in RSP_Val1
Byte 7: CHECKSUM – Checksum of Bytes 1 to 6 as explained above

RSP_EXT packet structure			
Byte 1	**..**	**Byte N**	**Byte N+1**
RSP bytes 1 to N			**RSP_EXT_CHECKSUM**

Byte 1:	First Byte of RSP_EXT
…	
Byte N:	N-nth Byte of RSP_EXT
Byte N+1:	RSP_EXT_CHECKSUM, checksum of Bytes 1 to N, calculated as explained earlier.

COMMANDS OVERVIEW

Commands are divided into several groups, based on purpose.

Device related commands

General purpose device related commands

GET_READER_TYPE	0x10
GET_READER_SERIAL	0x11
GET_SERIAL_NUMBER	0x40
GET_HARDWARE_VERSION	0x2A
GET_FIRMWARE_VERSION	0x29
GET_BUILD_NUMBER	0x2B
READER_KEY_WRITE	0x12
USER_DATA_READ	0x1B
USER_DATA_WRITE	0x1C
SELF_RESET	0x30

SET_UART_SPEED	0x70
RED_LIGHT_CONTROL	0x71
USER_INTERFACE_SIGNAL	0x26
SET_RF_ANALOG_SETTINGS	0x7D
GET_RF_ANALOG_SETTINGS	0x7E

Card related commands

General purpose card related commands

GET_CARD_ID	0x13
GET_CARD_ID_EX	0x2C
GET_DLOGIC_CARD_TYPE	0x3C
GET_LAST_CARD_ID_EX	0x7C

Trailer block manipulation commands

SECTOR_TRAILER_WRITE	0x1A
SECTOR_TRAILER_WRITE_UNSAFE	0x2F

Block manipulation commands

BLOCK_READ	0x16
BLOCK_WRITE	0x17
BLOCK_IN_SECTOR_READ	0x18
BLOCK_IN_SECTOR_WRITE	0x19

Linear data manipulation commands

LINEAR_READ	0x14
LINEAR_WRITE	0x15
LINEAR_FORMAT_CARD	0x25
LIN_ROW_READ	0x45

Value block manipulation commands

Direct block addressing

VALUE_BLOCK_READ	0x1D
VALUE_BLOCK_WRITE	0x1E
VALUE_BLOCK_INC	0x21
VALUE_BLOCK_DEC	0x22

Indirect block addressing

VALUE_BLOCK_IN_SECTOR_READ	0x1F
VALUE_BLOCK_IN_SECTOR_WRITE	0x20
VALUE_BLOCK_IN_SECTOR_INC	0x23
VALUE_BLOCK_IN_SECTOR_DEC	0x24

Commands for “asynchronous UID sending” feature

SET_CARD_ID_SEND_CONF	0x3D
GET_CARD_ID_SEND_CONF	0x3E
SET_BAD_SELECT_NR_MAX	0x3F
GET_BAD_SELECT_NR_MAX	0x44

Power saving commands

ENTER_SLEEP_MODE	0x46
LEAVE_SLEEP_MODE	0x47
AUTO_SLEEP_SET	0x4D
AUTO_SLEEP_GET	0x4E

Light and display commands

SET_DISPLAY_DATA	0x72
SET_SPEAKER_FREQUENCY	0x73
SET_DISPLAY_INTENSITY	0x74
GET_DISPLAY_INTENSITY	0x75

uFR BASE Control commands

UFR_XRC_LOCK_OPEN	0x60
UFR_XRC_SET_RELAY_STATE	0x61
UFR_XRC_GET_IO_STATE	0x62

Shared Ram card emulation commands

ENTER_SHARE_RAM_COMM_MODE	0x78
EXIT_SHARE_RAM_COMM_MODE	0x79

```
READ_SHARE_RAM                  0x7A
WRITE_SHARE_RAM                 0x7B
```

DEVICE RELATED COMMANDS

GENERAL PURPOSE DEVICE RELATED COMMANDS

GET_READER_TYPE (0x10)

It gives device (reader) type in size of 4 bytes which is hard coded in the firmware.
uFR Classic has value of 0xD1150021.
CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RSP packet is sent and after that also the RSP_EXT packet of 5 bytes which contains 4 byte DeviceType values (little-endian) and CHECKSUM byte.

Example:

```
Send CMD GET_READER_TYPE
55 10 AA 00 00 00 F6
```

Where

```
55 – CMD_HEADER
10 – CMD_CODE
AA – CMD_TRAILER
00 00 00 – CMD_EX_Length and CMD_Par0 and CMD_Par1 not used
F6 – CHECKSUM
```

Reader answer with RESPONSE – RSP packet followed by RSP_EXT packet

```
DE 10 ED 05 00 00 2D 21 00 15 D1 EC
```

Where RSP PACKET contains

```
DE – RSP_HEADER
10 – CMD_CODE
ED – RSP_TRAILER
05 – RSP_EXT_Length
00 00 – RSP_Val0 and RSP_Val1 not used
2D – CHECKSUM
```

and RSP_EXT contains

```
21 00 15 D1 – Device type (currently uFR Classic D1 15 00 21, little-endian notation)
EC – CHECKSUM
```

GET_READER_SERIAL (0x11)

It gives the device (reader) serial number with length of 4 bytes. On the older devices, this serial number has been read from EEPROM MFRC chip.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RESPONSE set is sent and after that also the RESPONSE EXT set of 5 bytes which contains 4 byte ReaderSerialNumber values (little-endian) and at the end one checksum byte.

Example:

```
Send CMD GET_READER_SERIAL
55 11 AA 00 00 00 F5
```

Where

```
55 – CMD_HEADER
11 – CMD_CODE
AA – CMD_TRAILER
00 00 00 – CMD_EX_Length and CMD_Par0 and CMD_Par1 not used
F5 – CHECKSUM
```

Reader answer with RESPONSE – RSP packet followed by RSP_EXT packet

```
DE 11 ED 05 00 00 2E 54 7E 1A 5D 74
```

Where RSP PACKET contains

```
DE – RSP_HEADER
11 – CMD_CODE
ED – RSP_TRAILER
05 – RSP_EXT_Length
00 00 – RSP_Val0 and RSP_Val1 not used
2E – CHECKSUM
```

and RSP_EXT contains

```
54 7E 1A 5D – Device type (currently serial is 5D 1A 7E 54, little-endian notation)
74 – CHECKSUM
```

GET_SERIAL_NUMBER (0x40)

Command returns reader serial number in string representation, like “UF123456”.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
Example:

```
Send CMD GET_SERIAL_NUMBER
55 40 AA 00 AA CC E0
```

Where

```
55 – CMD_HEADER
40 – CMD_CODE
AA – CMD_TRAILER
```

```
00 AA CC – CMD_EX_Length and CMD_Par0 and CMD_Par1 not used
E0 – CHECKSUM
```

Reader answer with RESPONSE – RSP packet followed by RSP_EXT packet

`DE 40 ED 09 00 00 81 55 46 31 32 33 34 35 36 1B`

Where RSP PACKET contains

```
DE – RSP_HEADER
40 – CMD_CODE
ED – RSP_TRAILER
09 – RSP_EXT_Length
00 00 – RSP_Val0 and RSP_Val1 not used
81 – CHECKSUM
```

and RSP_EXT contains

```
55 46 31 32 33 34 35 36 – Device readers number (currently serial is "UF123456")
1B – CHECKSUM
```

GET_HARDWARE_VERSION (0x2A)

Returns reader hardware version as two byte representation of higher and lower byte.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
High byte of hardware version is RSP_Val0.
Low byte of hardware version is PSP_Val1

Example:

```
CMD        55 2A AA 00 00 00 DC
RSP        DE 2A ED 00 01 01 20
```

GET_FIRMWARE_VERSION (0x29)

Returns reader firmware version as two byte representation of higher and lower byte.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
High byte of firmware version is RSP_Val0.
Low byte of firmware version is PSP_Val1.

Example:

```
CMD        55 29 AA 00 00 00 DD
RSP        DE 29 ED 00 03 09 17
```

GET_BUILD_NUMBER (0x2B)

Returns reader firmware build version as one byte representation.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.

Build number of firmware version is RSP_Val0.

Example:

```
CMD        55 2B AA 00 00 00 DB
RSP        DE 2B ED 00 C8 00 D7
```

READER_KEY_WRITE (0x12)

Function writes MIFARE key into internal EEPROM of MFRC531, at key index location (0 – 31).
• CMD_Par0 is key index
• CMD_Par1 is not in use
• array from 1st to 6th byte of CMD_EXT set contains 6-byte key
• 7th byte of CMD_EXT set is CHECKSUM

Example:

Write Key FF FF FF FF FF FF into key index 00

```
CMD        55 12 AA 07 00 00 F1
ACK        AC 12 CA 07 00 00 7A

CMD_EXT    FF FF FF FF FF FF 07
RSP        DE 12 ED 00 00 00 28
```

USER_DATA_READ (0X1B)

Function gives the 16 bytes from internal EEPROM user space.
The CMD_Par0 and CMD_Par1 are not in use.
• array from 1st to 16th byte of RSP_EXT set contains 16 bytes of user data
• 17th byte of RSP_EXT set is CHECKSUM.

Example:

```
CMD        55 1B AA 00 00 00 EB
RSP        DE 1B ED 11 00 00 40
RSP_EXT    6A 6A 00 00 36 00 00 00 30 00 32 00 38 00 41 00 54
```

USER_DATA_WRITE (0X1C)

Function writes 16 bytes into user space, which is 16 bytes part of internal EEPROM of MFRC531.
The CMD_Par0 and CMD_Par1 are not in use.
• array from 1st to 16th byte of CMD_EXT set contains 16 bytes of user data
• 17th byte of CMD_EXT set is CHECKSUM.

Example:

write into user space values we read in previous example (`6A 6A 00 00 36 00 00 00 30 00 32 00 38 00 41 00 54`)

```
CMD        55 1C AA 11 00 00 F9
ACK        AC 1C CA 11 00 00 72

CMD_EXT    6A 6A 00 00 36 00 00 00 30 00 32 00 38 00 41 00 54
RSP        DE 1C ED 00 00 00 36
```

SELF_RESET (0X30)

Function performs soft restart of device.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use

Example:

```
CMD        55 30 AA 00 00 00 D6

RSP        DE 30 ED 00 00 00 0A
RSP_EXT    03 55 55 BB
```

SET_UART_SPEED (0X70)

Function writes new value of UART's baud rate. For example 115200. Command sending is at current baud rate, ACK is at current baud rate, but response is at new baud rate. In future, the device will communicate at new baud rate.
The CMD_Par0 and CMD_Par1 are not in use.
• array from 1st to 4th byte of CMD_EXT set contains 4 byte long baud rate (litle-endian)
• 5th byte of CMD_EXT set is CHECKSUM.

Example:

```
CMD        55 70 AA 05 00 00 91
ACK        AC 70 CA 00 00 00 1D
CMD_EXT    00 01 C2 00
RSP        ED 70 DE ….......
```

RED_LIGHT_CONTROL (0X71)

This function turns on or off red LED light. If turned on, green LED will stop flashing.
The CMD_EXT set is not in use.
CMD_Par0 – 0x01 turn red LED on, 0x00 – turn red LED off.
CMD_Par1 is not in use.

Example:

To turn red LED ON, send CMD packet

```
CMD        55 71 AA 00 01 00 96
RSP        DE 71 ED 00 00 00 49
```

To turn red LED OFF, send CMD packet

```
CMD         55 71 AA 00 00 00 95
RSP         DE 71 ED 00 00 00 49
```

USER_INTERFACE_SIGNAL (0x26)

This function turns sound and light reader signals. Sound signals are performed by reader's buzzer and light signals are performed by reader's LEDs.
There are predefined signal values for sound and light:

light_signal_mode:		beep_signal_mode:	
0	None	0	None
1	Long Green	1	Short
2	Long Red	2	Long
3	Alternation	3	Double Short
4	Flash	4	Triple Short
		5	Triplet Melody

The CMD_EXT set is not in use.
CMD_Par0 is value of light signal mode (0 - 4)
CMD_Par1 is value of beep signal mode (0 - 5)

Example:

light signal mode is Long Green (1), beep signal mode is Long (2)

```
CMD         55 26 AA 00 01 02 E1
RSP         DE 26 ED 00 00 00 1C
```

SET_DISPLAY_DATA (0x72)

This feature working with LED RING 24 display module.
Function enables sending data to the display. A string of data contains information about the intensity of color in each cell of the display. Each cell has three LED (red, green and blue). For each cell of the three bytes is necessary. The first byte indicates the intensity of the green color, the second byte indicates the intensity of the red color, and the third byte indicates the intensity of blue color. For example, if the display has 16 cells, an array contains 48 bytes. Value of intensity is in range from 0 to 255.

CMD_Par0 number of bytes
CMD_Par1 not in use
CMD_EXT contains data for display with checksum

Example:

green = 0, red = 0xFF, blue = 0x80

```
CMD        55 72 AA 49 48 00 93
ACK        AC 72 CA 49 48 00 1C
CMD_EXT    00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80
00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80
00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80
00 FF 80 07
RSP        DE 72 ED 00 00 00 48
```

SET_DISPLAY_INTENSITY (0x74)

Function sets the intensity of light on the display. Value of intensity is in range 0 to 100.

CMD_Par0 is display intensity
CMD_Par1 not in use
CMD_EXT not in use

Example:

display intensity is 50

```
CMD        55 74 AA 00 32 00 C0
RSP        DE 74 ED 00 00 00 4E
```

GET_DISPLAY_INTENSITY (0x75)

Function gets the intensity of light on the display.
CMD_Par0 not in use
CMD_Par1 not in use
CMD_EXT not in use
RSP_EXT 1st byte is intensity, 2nd byte is checksum

Example:

```
CMD        55 75 AA 00 00 00 91
RSP        DE 75 ED 02 00 00 4B
RSP_EXT    32 39
```

SET_SPEAKER_FREQUENCY (0x73)

Function sets the frequency of the speaker. The speaker is working on this frequency until a new frequency setting. To stop the operation set frequency to zero.

Period of sound frequency calculated according to the following formula

period = 65535 - 1500000 / (2 * frequency in Hertz)

CMD_Par0 is low byte of sound's period

CMD_Par1 is high byte of sound’s period

Example:

set frequency of 1600Hz

```
CMD        55 73 AA 00 2B FE 60
RSP        DE 73 ED 00 00 00 47
```

SET_RF_ANALOG_SETTINGS (0x7D)

This function allows you to adjust the value of several registers on PN512. These are registers: RFCfgReg, RxThresholdReg, GsNOnReg, GsNOffReg, CWGsPReg, ModGsPReg. This can be useful if you want to increase the operation distance of card, or when it is necessary to reduce the impact of environmental disturbances.

CMD_Par0 type of communication with tag

ISO14443 type A	0x01
ISO14443 type B	0x02
ISO14443-4 212 Kbps	0x03
ISO14443-4 424 Kbps	0x04

CMD_Par1 0 - user settings, 1 - factory default settings

CMD_EXT
- 1st byte is value of RFCfgReg
- 2nd byte is value of RxThresholdReg
- 3rd byte is value of GsNOnReg
- 4th byte is value of CWGsPReg
- 5th byte is value of GsNOffReg for Type A or ModGsPReg for type B

For ISO14443-4 212 Kbps and ISO14443-4 424 Kbps CMD_EXT contains just first 2 bytes

Example:

RFCfgReg = 0x79, RxTesholdReg = 0x87, GsNonReg = 0x88, CWGsPReg = 0x20, GsNOffReg = 0x88

```
CMD       55 7D AA 06 01 00 8C
ACK       AC 7D CA 06 01 00 23
CMD_EXT   79 87 88 20 88 E5
RSP       DE 7D ED 00 00 00 55
```

GET_RF_ANALOG_SETTINGS (0x7E)

The function reads the value of the registers RFCfgReg, RxThresholdReg, GsNOnReg, GsNOffReg, CWGsPReg, ModGsPReg.

CMD_Par0 type of communication with tag

ISO14443 type A	0x01
ISO14443 type B	0x02
ISO14443-4 212 Kbps	0x03
ISO14443-4 424 Kbps	0x04

The CMD_EXT set is not in use.

RSP_EXT
- 1st byte is value of RFCfgReg
- 2nd byte is value of RxThresholdReg
- 3rd byte is value of GsNOnReg
- 4th byte is value of CWGsPReg
- 5th byte is value of GsNOffReg for Type A or ModGsPReg for type B

For ISO14443-4 212 Kbps and ISO14443-4 424 Kbps RSP_EXT contains just first 2 bytes

UFR_BASE_HD_LOCK_OPEN (0x60)

BASE HD uFR only.

Electric strike switches when the function called. Pulse duration determined by function.

CMD_Par0	pulse duration in ms low byte
CMD_Par1	pulse duration in ms high byte

Example:

Pulse duration is 300ms (0x12C)

```
CMD         55 60 AA 00 2C 01 B9
RSP         DE 60 ED 00 00 00 5A
```

UFR_BASE_HD_SET_RELAY_STATE (0x61)

BASE HD uFR only.
Function switches relay.

CMD_Par0	1 - relay on, 0 - relay off

Example:
Relay on.

```
CMD         55 61 AA 00 01 00 A6
RSP         DE 61 ED 00 00 00 59
```

UFR_BASE_HD_GET_IO_STATE (0x62)

BASE HD uFR only.
Function returns states of 3 IO pins.

RSP_EXT
1st byte 1- voltage at the intercom terminals detected, 0 - no voltage at the intercom terminals
2nd byte 1 - voltage at DIGIN pin is high, 0 - voltage at DIGIN pin is low.
3rd byte 1 - relay is turn on, 0 - relay is turn off

Example:

```
CMD        55 62 AA 00 00 00 A4
RSP        DE 62 ED 04 00 00 5C
RSP_EXT    01 00 01 07
```

CARD RELATED COMMANDS

For all the functions for operations with cards the following applies:
• They operates only with one card in the device field
• If there is no card in the field device return error NO_CARD (0x08).
• If there is more than one card in the field the behavior of the device is unpredictable but some of the next cases are possible:

- Gives NO_CARD error or
- Just one card is detected and the device gives its type (this is due to the lack of a cascade of selection and the collision process as described in the ISO14443 standard).

GENERAL PURPOSE CARD RELATED COMMANDS

GET_CARD_ID (0x13)

This function return the serial number of the card which is currently in the readers field and the one byte value that represents its type. For Mifare Classic 1K the type is 0x08, Mifare Classic 4k type is 0x18 and Mifare Classic Mini cards type is 0x09.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.

If everything operates as expected the RESPONSE set is sent and after that also the RESPONSE EXT set of 5 bytes which contains 4 byte Card UID values (little-endian) and CHECKSUM byte.
RSP_Val0 contains value of the card type.
This function applies only for card with 4-byte UID. For longer UID's, use GET_CARD_ID_EX (0x2C)

Example:

```
CMD        55 13 AA 00 00 00 F3
RSP        DE 13 ED 05 08 00 34
RSP_EXT    13 E2 0A 87 83
```

Where in RSP packet byte 05 represents RSP_EXT_length and byte 08 represents CardType – 0x08 – Mifare Classic.
RSP_EXT returns Card UID (little-endian) and CHECKSUM of UID bytes.

If error occurs, like NO_CARD, device will answer with ERR packet

```
CMD        55 13 AA 00 00 00 F3
ERR        EC 08 CE 00 00 00 31
```

Where byte 08 represents ERR_CODE for NO_CARD error.

GET_CARD_ID_EX (0x2C)

Use this function for cards with UID longer than 4 byte.
This function return the serial number of the card which is currently in the readers field, length of serial number (4 (UID size: single), 7 (UID size: double) or 10 (UID size: triple)), and the one byte value that represents its type. For Mifare Classic 1K the type is 0x08, Mifare Classic 4k type is 0x18 and Mifare Classic Mini cards type is 0x09.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RSP packet is sent and after that also the RSP_EXT packet of 11 bytes which contains card serial number and at the end one checksum byte.
RSP_Val0 contains value of the card type.
RSP_Val1 contains length of card serial number.

Example:

```
CMD        55 2C AA 00 00 00 DA

RSP        DE 2C ED 0B 08 04 1F
RSP_EXT    13 E2 0A 87 00 00 00 00 00 00 83
```

Where in RSP packet byte 0B represents RSP_EXT_Length, byte 08 means Card Type – Mifare Classic 1K, and byte 04 is length of card UID in RSP_EXT packet.
RSP_EXT packet contains card UID bytes and CHECKSUM.

If error occurs, like NO_CARD, device will answer with ERR packet

```
CMD        55 2C AA 00 00 00 DA
ERR        EC 08 CE 00 00 00 31
```

Where byte 08 represents ERR_CODE for NO_CARD error.

GET_LAST_CARD_ID_EX (0x7C)

This function returns UID of last card which was present in RF field of reader. It can handle all three known types: 4, 7 and 10 byte long UIDs. Difference with GetCardIdEx is that card does not be in RF field mandatory, UID value is stored in temporary memory area.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RSP packet is sent and after that also the RSP_EXT packet of 11 bytes which contains card serial number and at the end one checksum byte.
RSP_Val0 contains value of the card type.
RSP_Val1 contains length of card serial number.

Example:

```
CMD       55 7C AA 00 AA CC EC

RSP       DE 7C ED 0B 08 04 4F
RSP_EXT   52 DA D9 95 00 00 00 00 00 00 CB
```

Where in RSP packet byte 0B represents RSP_EXT_Length, byte 08 means Card Type – Mifare Classic 1K, and byte 04 is length of card UID in RSP_EXT packet.
RSP_EXT packet contains card UID bytes and CHECKSUM.

If error occurs, like NO_CARD, device will answer with ERR packet

```
CMD       55 7C AA 00 AA CC EC
ERR       EC 08 CE 00 AA CC 53
```

Where byte 08 represents ERR_CODE for NO_CARD error.

GET_DLOGIC_CARD_TYPE (0x3C)

This function returns card type according to following enumeration list:

DL_MIFARE_ULTRALIGHT	0x01
DL_MIFARE_ULTRALIGHT_EV1_11	0x02
DL_MIFARE_ULTRALIGHT_EV1_21	0x03
DL_MIFARE_ULTRALIGHT_C	0x04
DL_NTAG_203	0x05
DL_NTAG_210	0x06
DL_NTAG_212	0x07
DL_NTAG_213	0x08

DL_NTAG_215	0x09
DL_NTAG_216	0x0A
MIKRON_MIK640D	0x0B
DL_MIFARE_MINI	0x20
DL_MIFARE_CLASSIC_1K	0x21
DL_MIFARE_CLASSIC_4K	0x22
DL_MIFARE_PLUS_S_2K	0x23
DL_MIFARE_PLUS_S_4K	0x24
DL_MIFARE_PLUS_X_2K	0x25
DL_MIFARE_PLUS_X_4K	0x26
DL_MIFARE_DESFIRE	0x27
DL_MIFARE_DESFIRE_EV1_2K	0x28
DL_MIFARE_DESFIRE_EV1_4K	0x29
DL_MIFARE_DESFIRE_EV1_8K	0x2A

Example:

```
CMD       55 3C AA 00 00 00 CA
RSP       DE 3C ED 00 21 00 35
```

Where byte 21 in RSP packet represents card type – 0x21 – Mifare Classic 1K.

If error occurs, like NO_CARD, device will answer with ERR packet

```
CMD       55 3C AA 00 00 00 CA
ERR       EC 08 CE 00 00 00 31
```

Where byte 08 represents ERR_CODE for NO_CARD error.

FUNCTIONS FOR READING AND WRITING THE DATA INTO THE CARD

Authentication mode considerations for Mifare Classic tags

The parameter AUTH_MODE affects all the functions and determines authorization before reading or entering data in the card sector. This parameter can have the following values:

• **RKA_AUTH1A**	**0x00**
• **RKA_AUTH1B**	**0x01**
• **AKM1_AUTH1A**	**0x20**
• **AKM1_AUTH1B**	**0x21**
• **AKM2_AUTH1A**	**0x40**
• **AKM2_AUTH1B**	**0x41**
• **PK_AUTH1A**	**0x60**
• **PK_AUTH1B**	**0x61**

From the names of each of these constants can be concluded that the suffixes 1A and 1B indicate that you want to perform authentication key A or key B.

Prefixes in the names of constants represents modes of authentication, as following:

RKA – abbreviation of Reader Key Authentication. This means that authentication will be done with one of the 32 keys that are stored in reader device. It is assumed that as one of the command parameter that is sent to the reader is the index of the desired key. Indexes are in range 0..31.
AKM1 and AKM2 – abbreviation of Automatic Key Modes. This means that the authentication will be done automatically with the keys stored in reader device and they are indexed on the basis of the block or sector address where the writing or reading is currently done.
This applies to any function for card writing and reading, even for linear modes. I
When using AKM1 mode, keys in range 0 to 15 are used as Key A for corresponding sectors, while keys indexed from 16 to 31 are used as Key B for corresponding sectors.

Example for AKM1 keys indexes:

```
Key[00] = Key A Sector 0; Key [01] = Key A Sector [1]; … Key [15] = Key A Sector 15;
Key[16] = Key B Sector 0; Key [17] = Key B Sector [1]; … Key [31] = Key B Sector 15;
```

When using AKM2, keys are indexed by odd and even order, so even keys indexes are used as Key A and odd keys indexes are used as Key B.

Example for AKM1 keys indexes:

```
Key[00] = Key A Sector 0; Key [02] = Key A Sector [1]; … Key [30] = Key A Sector 15;
Key[1] = Key B Sector 0; Key [3] = Key B Sector [1]; … Key [31] = Key B Sector 15;
```

For 4k cards, which have 24 sectors more than 1k cards (total 40) for sectors 16 to 31 is used the same method as for indexing sectors 0 to 15 and for sectors 32 to 39 used the same method of indexing and for sectors 0 to 8.
PK – abbreviation for Provided Key refers to the authentication which is performed with key that is sent as a command parameter. Generally, this mode of authentication should be avoided due to the low level of security it provides, since key is passed as command parameter.

Authentication mode considerations for NTAG 21x and other T2T tags (supported from firmware version 3.9.10)

NTAG 21x and some other T2T tags (such as Ultralight EV2) support different authentication method from the Mifare Classic tags. NTAG 21x tags authentication is done using ISO 14443A-3 PWD_AUTH command, requiring from the reader to transmit secret code (PWD) of 4 bytes the tag, which responds with a PACK (PWD ACKNOWLEDGE). If the transmitted code is equal to that programmed in the tag, he responds with the correct PACK (length 2 bytes). PWD and PACK is typically written into the tag during the personalization process. The configuration pages are used to configure the memory access restriction of the tag. In order to familiarize with the methods of authentication of the NTAG 21x we recommend that you read "NTAG210 / 212, NFC Forum Type 2 Tag IC compliant with 48/128 bytes user memory Product data sheet" or "NTAG213 / 215/216, NFC Forum Type 2 Tag IC compliant with 144/504/888 bytes user memory data sheet Product" or "MF0ULx1, MIFARE Ultralight EV1 - Contactless IC ticket Product data sheet" that can be found on the manufacturer website. All these documents are marked "PUBLIC COMPANY".

NTAG 21x, Ultralight EV2 and other T2T tags supporting PWD_AUTH, practically use 6 bytes (4 bytes that make up the PWD and 2 bytes of the PACK response) in our uFR readers we use the same mechanism as for Mifare Classic tags. The only difference is that a combined PWD (first 4 bytes of the key) and PACK (the last 2 bytes of the key) now forming a key (6 bytes in length). The resultant key can be prepared in advance and written in the card reader internal EEPROM (NV Memory) for using with Reader Key Authentication (RKA) method, or sent as a parameter of the uFR_COM protocol command using Provided Key (PK) methods.

Note: Reader Key Authentication (RKA) methods with NTAG 21x, Ultralight EV2 and other T2T tags can not be used with uFR Classic and uFR Advanced commercial readers. These methods are possible only with newer reader series like uFR nano, uFR card size readers and HD Base with uFR support installed. On older models for this purpose can be used only Provided Key (PK) methods.

The following constants are declared for the parameter that determines the method for PWD_AUTH for NTAG 21x, Ultralight EV2 and other T2T tags:

```
T2T_NO_PWD_AUTH 0x00
T2T_RKA_PWD_AUTH 0x01
T2T_PK_PWD_AUTH 0x61
```

These constants are used with the following uFR_COM protocol commands:

```
BLOCK_READ
BLOCK_WRITE
LINEAR_READ
LINEAR_WRITE
LIN_ROW_READ
```

and passed as a parameter value controls AUTH_MODE. If you use any other undeclared value as AUTH_MODE, the effect will be the same as if you sent T2T_NO_PWD_AUTH.

When for the AUTH_MODE command parameter you send T2T_RKA_PWD_AUTH or T2T_PK_PWD_AUTH reader will always try to perform PWD_AUTH regardless of the settings in the configuration pages of the tag. For the implementation of the adequate authentication scheme developer is responsible to use T2T_NO_PWD_AUTH for access of the public data that are not protected by a pair of PWD, PACK.

TRAILER BLOCK MANIPULATION COMMANDS

Special blocks called "trailer blocks" defines access bits and rights for Keys A and B for each sector. To read more, refer to NXP documentation about Mifare cards, see http://www.nxp.com/documents/data_sheet/M001053_MF1ICS50_rev5_3.pdf and http://www.nxp.com/documents/data_sheet/MF1S50YYX.pdf

SECTOR_TRAILER_WRITE (0x1A)

Function is used to write keys and access bits into the trailers of the sector. It could be used or sector address mode (without need for block_in_sector_address to be sent because the given sector is always known) either the block address mode that determines the addressing_mode u CMD_EXT set parameter which can have the following values:
BLOCK_ADDRESS_MODE = 0
SECTOR_ADDRESS_MODE = 1
Access bits are sent separately as 4 bytes that has possible values 0 up to 7.
The device Firmware is formatting the access bits according to the cards specification irreversible blocking of that sector.

The CMD_EXT set is used and its length depends on the authentication mode that is in use.
CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is an unencrypted key A for writing
• in 11th to 14th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 15th to 20th byte of the set contains an unencrypted key B for writing

• 21st byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is an unencrypted key A for writing
• in 11th to 14th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 15th to 20th byte of the set contains an unencrypted key B for writing
• 21st byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing_mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• array from 5th up to 10th byte contains 6-byte key.
• in 11th to 16th byte of the set is an unencrypted key A for writing
• in 17th to 20th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 21st do 26th byte of the set contains an unencrypted key B for writing
• 27th byte contains checksum

If everything is done as it should it returns the RESPONSE set.
RESPONSE_EXT is not used.

Example:

authentication RKA key A, key number 0, sector address 0, addressing mode 1, key A = 0xFFFFFFFFFFFF, key B = 0xFFFFFFFFFFFF, access bits values 0, 0, 0, 1

```
CMD       55 1A AA 15 00 00 F7
ACK       AC 1A CA 15 00 00 70
```

```
CMD_EXT   00 00 01 69 FF FF FF FF FF FF 00 00 00 01 FF FF FF FF FF FF 70
RESP      DE 1A ED 00 00 00 30
```

SECTOR_TRAILER_WRITE_UNSAFE (0x2F)

It operates as SECTOR_TRAILER_WRITE except it send already formatted sector trailer block to be written without the access bits value check. The command is unsafe because it could lead to irreversible blocking of the entire sector of the card due to improperly formatted value of access bits. Made only for advanced users.

The CMD_EXT set is used and its length depends on the authentication mode that is in use.
CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 u CMD set contains readers index key
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing_mode
• 4th byte of the set contains dummy value
• in 5th to 20th byte of the set is the content of the sector trailer for writing
• 21st byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing_mode
• 4th byte of the set contains dummy value
• in 5th to 20th byte of the set is the content of the sector trailer for writing
• 21st byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing_mode
• 4th byte of the set contains dummy value
• array from 5th up to 10th bytes contains 6-byte key.
• in 11th to 26th byte of the set is the content of the sector trailer for writing
• 27th byte contains checksum
If everything is done as it should it returns the RESPONSE set.
RESPONSE_EXT is not used.

Example:

authentication RKA key A, key number 0, sector address 0, addressing mode 1, key A = 0xFFFFFFFFFFFF, key B = 0xFFFFFFFFFFFF, access bits values 0xFF078069 (default configuration)

```
CMD        55 2F AA 15 00 00 CC
ACK        AC 2F CA 15 00 00 63

CMD_EXT    00 00 01 00 FF FF FF FF FF FF FF 07 80 69 FF FF FF FF FF FF 17
RESP       DE 2F ED 00 00 00 23
```

BLOCK MANIPULATION COMMANDS

Following commands used direct block addressing, meaning that blocks are indexed in range 0 to 63 for Mifare 1K cards.

BLOCK_READ (0x16)

Reads the whole data block from the card which is in the reader field.
The CMD_EXT set is used and its length depends on authentication mode that is used.

CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains key index in the reader
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• 5th byte contains checksum

Example:

read block 01 with RKA_AUTH1A

```
CMD        55 16 AA 05 00 00 F3
ACK        AC 16 CA 05 00 00 7C

CMD_EXT    01 00 00 00 08

RSP        DE 16 ED 11 00 00 3B
RSP_EXT    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 07
```

AKMy_AUTH1x:

• CMD_Par1 is not used.

• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• 5th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• array from 5th to 10th byte contains 6-byte key.
• 11th byte contains checksum
If all operates as it should it turns the RESPONSE set and the RESPONSE_EXT is following with 16
read bytes and checksum at the end.

BLOCK_WRITE (0x17)

Writes the whole data block into the card that is currently in the readers field. Address mode is used for so called block addressing where for example the first block on Mifare Classic 1k has an address 0 and the last one has the address 63. This command doesn't allow the direct writing into the sector trailer and in the case of its addressing it gives back the FORBIDEN_DIRECT_WRITE_IN_SECTOR_TRAILER.

The CMD_EXT set is used and its length depends on the authentication mode that is in use.

CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• in 5th to 20th byte of set are placed data for writing into the data block
• 21st byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• in 5th to 20th byte of the set are placed the data for writing into the data block
• 21st byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address

• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data
• array from 5th to 10th byte contains 6-byte key.
• in 11th too 26th byte are placed the data for writing into the data block
• 27th byte contains checksum.

If everything is done as it should device answer with RSP packet.

Example:

write “01 02 03 04 05 06 07 08” into block 1 using key “FF FF FF FF FF FF”

```
CMD        55 17 AA 1B 60 00 9A
ACK        AC 17 CA 1B 60 00 11

CMD_EXT    01 00 00 00 FF FF FF FF FF FF 01 02 03 04 05 06 07 08 00 00 00
00 00
           00 00 00 10
RSP        DE 17 ED 00 00 00 2B
```

BLOCK_IN_SECTOR_READ (0x18)

It has the same function as the BLOCK_READ but uses the different address mode for so called sector addressing where is always given the address of the sector and the sector block (as specified in the NXP documentation for Mifare Classic cards). The first sector of the Mifare Classic 1k card for example has the address 0 and the last one has 15. The block addresses of the sector are defined in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second line of address space (the second 2k that is 32nd up to 39th sector) have the block addresses in sector 0 to 15 and the 15th is sector trailer.

Communication command protocol is the same as with BLOCK_READ with following exception:

• 1st byte of the CMD_EXT set contains block_in_sector_address
• 2nd byte of the CMD_EXT set contains sector_address
• 3rd and 4th byte of the CMD_EXT set contains dummy data

Example:

read block 0 in sector 0 with RKA_AUTH1A, key number 0

```
CMD        55 18 AA 05 00 00 E9
ACK        AC 18 CA 05 00 00 82

CMD_EXT    00 00 00 00 07
```

```
RSP        DE 18 ED 11 00 00 41
RSP_EXT    47 8F 90 61 39 08 04 00 01 F1 0A F0 1A A2 EB 1D 4F
```

BLOCK_IN_SECTOR_WRITE (0x19)

Has the same function as the BLOCK_WRITE but uses the different address mode, so called sector addressing where the sector address and the address of the block in the sector is always given (as mentioned in NXP documentation for Mifare Classic cards). For example the first sector on Mifare Classic 1k card has the address 0 and the last one has the address 15. The block addresses in sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second line of address space (the second 2k that is 32nd up to 39th sector) have the block addresses in sector 0 to 15 and the 15th is sector trailer.
Communication command protocol is the same as with BLOCK_WRITE with following exception:

• 1st byte of CMD_EXT set contains block_in_sector_address
• 2nd byte of CMD_EXT set contains sector_address
• 3rd and 4th byte of CMD_EXT set contains dummy data

Example:

write block 1 in sector 0 with RKA_AUTH1A, key number 0

```
CMD        55 19 AA 15 00 00 FA
ACK        AC 19 CA 15 00 00 71
CMD_EXT    01 00 00 00 00 00 00 00 00 00 FF 07 80 69 FF FF FF FF FF FF 17
RSP        DE 19 ED 00 00 00 31
```

LINEAR DATA MANIPULATION COMMANDS

LINEAR_READ (0x14)

Linear read data from the card. This command concatenates data for successive blocks and sectors into one array of data. It performs something like “continuous reading” of data. It is very convenient for reading data from more blocks or sectors which are in successive order.

The CMD_EXT set is used whose length depends on the mode of authentication that is used.
CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT sets contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains key index in the
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• 5th byte contains checksum

Example:

Read linear data from 0 to 63, length is 64 bytes, using RK AUTH1A

```
CMD        55 14 AA 05 00 00 F5
ACK        AC 14 CA 05 00 00 7E

CMD_EXT    00 00 40 00 47
RSP        DE 14 ED 41 00 00 6D
```

```
and DATA we asked for in RSP_EXT
```

```
31 32 33 34 35 36 37 38 39 30 00 00 00 00 00 31
32 33 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

```
With checksum
38
```

AKMy_AUTH1x:

- CMD_Par1 is not used.
- 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
- 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
- 5th byte contains checksum

Example: Read linear data from 0 to 31, length is 32 bytes, using AKM1 AUTH1A

```
CMD        55 14 AA 05 20 00 D5
ACK        AC 14 CA 05 20 00 5E

CMD_EXT    00 00 20 00 27
RSP        DE 14 ED 21 00 00 0D
```

```
and DATA we asked for in RSP_EXT
31 32 33 34 35 36 37 38 39 30 00 00 00 00 00 31
32 33 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

```
With checksum
38
```

Example: Read linear data from 0 to 31, length is 32 bytes, using AKM1 AUTH1B

```
CMD         55 14 AA 05 21 00 D6
ACK         AC 14 CA 05 21 00 5D

CMD_EXT     00 00 20 00 27
RSP         DE 14 ED 21 00 00 0D
```

```
and DATA we asked for in RSP_EXT
```

```
31 32 33 34 35 36 37 38 39 30 00 00 00 00 00 31
32 33 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

```
With checksum
38
```

Same applies to AKM2 AUTHA and AUTHB commands.

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• array from 5th do 10th byte contains 6-byte key.
• 11th byte contains checksum.

Example: Read linear data from 16 to 31, length is 16 bytes, using PK AUTH1B and provided key 6 x FF

```
CMD         55 14 AA 0B 61 00 88
ACK         AC 14 CA 0B 61 00 1F

CMD_EXT     10 00 10 00 FF FF FF FF FF FF 07
RSP         DE 14 ED 11 00 00 3D
```

```
and DATA we asked for in RSP_EXT
```

```
32 33 00 00 00 00 00 00
00 00 00 00 00 00 00 00
```

```
with checksum
08
```

If everything operates as expected the RSP packet is sent and after that also the RSP_EXT with number of bytes according to the data_length command with checksum at the end.
In case the card is removed from the field or in case of wrong authentication including that some block is read anyway, it turns ERR set with NO_CARD error code or AUTH_ERROR and then the ERR_EXT set which contains the array of the read bytes and CHECKSUM at the end.

LINEAR_READ command utilise FAST_READ ISO 14443-3 command with NTAG21x and Mifare Ultralight EV1 tags.

LINEAR_WRITE (0x15)

Linear data writing into the card which is currently in the field of the reader. The verification of each written block is done during the writing.

The CMD_EXT set is used and its length depends on the authentication mode that is used

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT sets contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains key index in the reader
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• from 5th byte up (data_length + 4) contains data array for writing
• (data_length + 5) byte contains checksum

Example: Write 8 bytes into card string at linear address 08, using RK_AUTH1A, bytes are 10 11...17

```
CMD       55 15 AA 0D 00 00 EE
ACK       AC 15 CA 0D 00 00 85

CMD_EXT   08 00 08 00 10 11 12 13 14 15 16 17 07
RSP       DE 15 ED 00 00 00 2D
```

We can check now if bytes are written using previous examples of LinearRead command.

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• from 5th byte up (data_length + 4) contains data array for writing
• (data_length + 5) byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• array from 5th do 10th byte contains 6- byte key

• 11th byte and up to (data_length + 10) contains data array for writing
• (data_length + 11) byte contains checksum.

If everything went as expected device answer with RSP packet.
In error case it turns the ERR packet where the RSP_Val0 contains the number of eventual written bytes.

LINEAR_FORMAT_CARD (0x25)

The CMD_EXT set is used and its length depends on the authentication mode that is used.
Since this command can erase data or block card reading if wrong access bits are provided, we strongly suggest to test it first through SDK API examples to figure out what this command does.
For pure erasing data or filling card with 0x00 without changing the keys, it is much easier to use Linear_Write command.

Usage:
CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value
• 4th byte of the set has 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is new key A
• in 11th to 16th byte of the set is new key B
• 17th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value
• 4th byte of the set has 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is new key A
• in 11th to 16th byte of the set is new key B
• 17th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value

- 4th byte of the set has 9-byte sector trailer value (anything could be written)
- array from 5th up to 10th byte contains 6-byte key for authentication (previous)
- in 11th to 16th byte of the set is new key A
- in 17th to 22nd byte of the set is new key B
- 23rd byte contains checksum

If everything is done as it should device answer with RSP packet.
RSP_EXT is not used.

Example:

Key A is 0xFFFFFFFFFFFF, Key B is 0xFFFFFFFFFFFF, access bits value for blocks is 0, access bits value for sector trailers is 1, authentication mode is RKA_AUTH1A, key number is 0

```
CMD       55 25 AA 11 00 00 D2
ACK       AC 25 CA 11 00 00 59
CMD_EXT   00 01 00 69 FF FF FF FF FF FF FF FF FF FF FF FF 6F
RSP       DE 25 ED 00 10 00 0D
```

LIN_ROW_READ(0x45)

Functions allow you to quickly read data from the card including the sector trailer blocks.
These functions are very similar to the functions for linear reading of users data space.
Using this command is the same as using the command LINEAR_READ(0x14)

The CMD_EXT set is used whose length depends on the mode of authentication that is used.
CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT sets contains:

RKA_AUTH1x:

- CMD_Par1 in CMD set contains key index in the
- 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
- 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
- 5th byte contains checksum

AKMy_AUTH1x:

- CMD_Par1 is not used.
- 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
- 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
- 5th byte contains checksum

PK_AUTH1x:

- CMD_Par1 is not used.
- 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
- 3rd and 4th byte of CMD_EXT set contains data_length (little endian)

• array from 5th do 10th byte contains 6-byte key.
• 11th byte contains checksum.

Example:

Read data from 0 to 47, length is 48 bytes, using RK AUTH1A key number 0

```
CMD        55 45 AA 05 00 00 C6
ACK        AC 45 CA 05 00 00 2D
CMD_EXT    00 00 30 00 37
RSP        DE 45 ED 31 00 00 4E
RSP_EXT    47 8F 90 61 39 08 04 00 01 F1 0A F0 1A A2 EB 1D 00 00 00 00 00
00 FF
           07 80 69 FF FF FF FF FF FF 00 00 00 00 00 00 FF 07 80 69 FF FF
FF FF
           FF FF 4F
```

VALUE BLOCK MANIPULATION COMMANDS

DIRECT BLOCK ADDRESSING

VALUE_BLOCK_READ (0x1D)

Reads the 4-byte value of the “value block” of the card which is currently in the reading field. Address mode that is used is so called block addressing where for example the first block of Mifare Classic 1k card has the address 0 and the last one has the address 63.

The CMD_EXT set is used and its length depends on the authentication mode that is used. CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• 5th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• 5th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• array from 5th up to 10th byte contains 6-byte key.
• 11th byte contains checksum

If everything is OK, device answer with RSP packet followed by RSP_EXT containing 4-byte value and checksum.
RSP_Val0 contains block address (read from block value for powerful backup as mentioned in the Mifare card documentation).
In the case of error the VALUE_BLOCK_ADDR_INVALID (read value of the value block is formatted properly but the address bytes aren't) it returns ERR_EXT set which contains the value of the value block.

Notice that value is in little-endian notation, where negative values are stored as "Two complement's".

Example:

Read Value Block 05 with PK_AUTH1A:

```
CMD        55 1D AA 0B 60 00 90
ACK        AC 1D CA 0B 60 00 17

CMD_EXT    05 00 00 00 FF FF FF FF FF FF 0C
RSP        DE 1D ED 05 00 00 32
RSP_EXT    00 00 00 00 07
```

VALUE_BLOCK_WRITE (0x1E)

Store 4-byte value into "value block".

This command disallow the writing into the trailers of the sector and in case of their addressing it returns the FORBIDEN_DIRECT_WRITE_IN_SECTOR_TRAILER.

The CMD_EXT set is used and its length depends on the authentication mode that is used.

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the CMD_EXT set contains block_address
• 2nd and 3rd byte of the CMD_EXT set contains dummy data
• 4th byte contains value address
• in 5th to 8th byte of the set is placed the data for writing into the value block
• 9th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd and 3rd byte of the CMD_EXT set contains dummy data
• 4th byte contains value address
• in 5th to 8th byte of the set is placed the data for writing into the value block
• 9th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd and 3rd byte of the CMD_EXT set contains dummy data
• 4th byte contains value address
• array from 5th up to 10th byte contains 6-byte key.
• in 11th to 14th byte of the set is placed the data for writing into the value block
• 15th byte contains checksum

Example: Store value 01 01 01 01 into block 5 using PK_AUTH1A key FF FF FF FF FF FF

```
CMD        55 1E AA 0F 60 00 95
ACK        AC 1E CA 0F 60 00 1E

CMD_EXT    05 00 00 05 FF FF FF FF FF FF 01 01 01 01 07
RSP        DE 1E ED 00 00 00 34 DE
```

If everything is OK, device answer with RSP packet. RSP_EXT is not used.

Notice that value is in little-endian notation, where negative values are stored as “Two complement's”. For example, decimal value 65535 should be stored as FF FF 00 00.

VALUE_BLOCK_INC (0x21)

It increases the value of the addressed value block for the 4-byte value increment_val that is send as a command parameter and is been used for so-called block address mode.

The CMD_EXT set is used and its length depends on the authentication mode that is used.

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• in 5th to 8th byte set is increment_val
• 9th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• in 5th to 8th byte set is increment_val
• 9th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• array from 5th up to 10th byte contains 6-byte key
• in 11th to 14th bytes of the set is increment_val
• 15th byte contains checksum.

If everything is OK, device answer with RSP packet. RSP_EXT packet is not used.

Example:

Increase Value Block 5 with "F0 F0 F0 F0" using PK_AUTH1A with key FF FF FF FF FF FF

```
CMD        55 21 AA 0F 60 00 B8
ACK        AC 21 CA 0F 60 00 2F

CMD_EXT    05 00 00 00 FF FF FF FF FF FF F0 F0 F0 F0 0C
RSP        DE 21 ED 00 00 00 19 DE
```

Notice that when we read now Value Block 5 we will get
RSP and RSP_EXT DE 1D ED 05 05 00 35 F1 F1 F1 71 87,
with value F1 F1 F1 71, stored in little-endian notation, where byte 71 is represented in Two Complement's manner (change of sign +/-).

VALUE_BLOCK_DEC (0x22)

Decrement the value of the addressed value block for 4-byte value decrement_val which is sent as the command parameter. The so-called block address mode is used.

The CMD_EXT set is used and the length of the authentication mode is used.

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data
• in 5th to 8th byte of the set is decrement_val
• 9th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data
• in 5th to 8th byte of the set is decrement_val
• 9th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• array from 5th up to 10th byte contains 6-byte key.
• in 11th to 14th byte of the set is decrement_val
• 15th byte contains checksum.

If everything is OK, device answer with RSP packet. RSP_EXT packet is not used

Example:

Decrement Value Block 5 with 00 00 00 F0 using PK_AUTH1A with key FF FF FF FF FF FF

```
CMD         55 22 AA 0F 60 00 B9
ACK         AC 22 CA 0F 60 00 32

CMD_EXT     05 00 00 00 FF FF FF FF FF FF 00 00 00 F0 FC
RSP         DE 22 ED 00 00 00 18
```

Notice that when we read now Value Block 5 we will get
`RSP and RSP_EXT    DE 1D ED 05 05 00 35    F1 F1 F1 01 F7`
with value   F1 F1 F1 01, stored in little-endian notation, where byte 01 is represented in Two Complement's manner (change of sign +/-).

INDIRECT BLOCK ADDRESSING

VALUE_BLOCK_IN_SECTOR_READ (0x1F)

It operates as VALUE_BLOCK_READ but uses the different address mode, so-called sector addressing where are always given the sector address and the block address in the sector (as mentioned in NXP documentation for Mifare Classic cards).
For example the first sector of the Mifare Classic 1k card has the 0 and the last one has the address 15. Block addresses in the sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second half of address space (second 2k with 32 to 39 sector) the addresses of the blocks in sector 0 to 15 and the block 15 is sector trailer.

Communication command protocol is the same as with VALUE_BLOCK_READ with following exception:

• 1st byte of the CMD_EXT set contains block_in_sector_address
• 2nd byte of the CMD_EXT set contains sector_address
• 3rd and 4th byte of the CMD_EXT set contains dummy data.

Device will answer with RSP and RSP_EXT. RSP_Val0 contains direct block address.

Example:

Read Value Block 01 in Sector 01 (is equal to Value Block 5 using direct addressing) using PK_AUTH1A mode with key FF FF FF FF FF FF

```
CMD         55 1F AA 0B 60 00 92
ACK         AC 1F CA 0B 60 00 19

CMD_EXT     01 01 00 00 FF FF FF FF FF FF 07
RSP         DE 1F ED 05 05 00 33
RSP_EXT     F1 F1 F1 01 F7
```

VALUE_BLOCK_IN_SECTOR_WRITE (0x20)

It operates as VALUE_BLOCK_WRITE but uses different address mode, so-called sector addressing where are always given the sector address and the block address in the sector (as mentioned in NXP documentation for Mifare Classic cards). For example the first sector of the Mifare Classic 1k card has the 0 and the last one has the address 15. Block addresses in the sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second half of address space (second 2k with 32 to 39 sector) the addresses of the blocks in sector 0 to 15 and the block 15 is sector trailer.
Communication command protocol is the same as with VALUE_BLOCK_IN_SECTOR_READ with following exception:

- 1st byte of the CMD_EXT set contains block_in_sector_address
- 2nd byte of the CMD_EXT set contains sector_address
- 3rd and 4th byte of the CMD_EXT set contains dummy data

Example:

Write Value Block 00 in Sector 01 (is equal to Value Block 5 using direct addressing) value “80 80 80 80” using PK_AUTH1A mode with key FF FF FF FF FF FF

```
CMD       55 20 AA 0F 60 00 B7
ACK       AC 20 CA 0F 60 00 30

CMD_EXT   01 01 00 00 FF FF FF FF FF FF 80 80 80 80 07
RSP       DE 20 ED 00 00 00 1A
```

VALUE_BLOCK_IN_SECTOR_INC (0x23)

It operates as VALUE_BLOCK_IN_SECTOR_INC but uses the different address mode, so-called sector addressing where are always given the sector address and the block address in the sector (as mentioned in NXP documentation for Mifare Classic cards). For example the first sector of the Mifare Classic 1k card has the 0 and the last one has the address 15. Block addresses in the sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second half of address space (second 2k with 32 to 39 sector) the addresses of the blocks in sector 0 to 15 and the block 15 is sector trailer.
Communication command protocol is the same as with VALUE_BLOCK_INC with following exception:

- 1st byte of the CMD_EXT set contains block_in_sector_address
- 2nd byte of the CMD_EXT set contains sector_address
- 3rd and 4th byte of the CMD_EXT set contains dummy data.

Example:

```
CMD        55 23 AA 0F 60 00 BA
ACK        AC 23 CA 0F 60 00 31

CMD_EXT    01 01 00 00 FF FF FF FF FF FF 60 60 60 60 07
RSP        DE 23 ED 00 00 00 17
```

VALUE_BLOCK_IN_SECTOR_DEC (0x24)

It operates as VALUE_BLOCK_IN_SECTOR_DEC but uses different address mode, so-called sector addressing where are always given the sector address and the block address in the sector (as mentioned in NXP documentation for Mifare Classic cards). For example the first sector of the Mifare Classic 1k card has the 0 and the last one has the address 15. Block addresses in the sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second half of address space (second 2k with 32 to 39 sector) the addresses of the blocks in sector 0 to 15 and the block 15 is sector trailer.
Communication command protocol is the same as with VALUE_BLOCK_DEC with following exception:

• 1st byte of the CMD_EXT set contains block_in_sector_address
• 2nd byte of the CMD_EXT set contains sector_address
• 3rd and 4th byte of the CMD_EXT set contains dummy data

Example:

```
CMD        55 24 AA 0F 60 00 BB
ACK        AC 24 CA 0F 60 00 34

CMD_EXT    01 01 00 00 FF FF FF FF FF FF 60 60 60 60 07
RSP        DE 24 ED 00 00 00 1E
```

COMMANDS FOR “ASYNCHRONOUS UID SENDING” FEATURE

This feature “Async UID sending” is capability of reader device to send Card UID immediately when card enters into device RF field, without any action initiated by host. This is also exception from rule that communication is always initiated by host to device. Feature can be turned on and off. Baudrate for this feature is different than baudrate of device,.e.g. it can be different. Prefix and suffix are bytes that are used to diversify UID's, like header and trailer bytes of UID.
Device can send UID encapsulated in [Prefix] and [Suffix] when card enters into RF field.
Device can also send “empty UID” when card leaves RF field, meaning only [Prefix][Suffix] will be sent.

Best practice is to set Baud rate different than device communication speed, anything bigger than 9600 Bps to avoid colision with standard communication between device and host.

SET_CARD_ID_SEND_CONF (0x3D)

Set the asynchronously card ID sending parameters.

CMD_Par0 contains send enable flag (bit 0), prefix enable flag (bit 1) and send removed enable flag (bit2).
When using option Send removed flag, Prefix byte is mandatory
1st byte of the CMD_EXT contains prefix character
2nd byte of the CMD_EXT contains suffix character
array from 3rd byte up to 6th byte of the CMD_EXT contains baud rate value
7th byte of the CMD_EXT contains internal CRC (xor of bytes CMD_Par0 to 6th byte + 7)
8th byte of the CMD_EXT contains checksum

If everything is OK, device answer with RSP packet. RSP_EXT is not used.

Example:

```
CMD       55 3D AA 08 07 00 D4 (send command 3D, bits 0,1,2 high), D4
checksum
ACK       AC 3D CA 08 07 00 5B (ACK OK)

CMD_EXT   CC EE 80 25 00 00 87 07 (prefix CC, suffix EE, speed 9600
(0x2580),
                                  (87 checksum -
07,00,CC,EE,80,25,00,00),
                                  (07 - checksum of CMD_EXT)
RSP       DE 3D ED 00 00 00 15      (RESPONSE OK)speed 9600 (0x2580),
```

When card enter the field, event will occur:

```
HEX   CC 30 34 32 32 43 33 36 32 34 42 32 44 38 31 EE
ASCII     ?  0  4  2  2  C  3  6  2  4  B  2  D  8  1  ?

meaning card UID is 04 22 C3 62 4B 2D 81
```

On card removal, event will occur:

```
CC EE
```

To disable feature, send bits 0,1,2 low:

```
CMD   55 3D AA 00 00 00 C9
RSP   DE 3D ED 00 00 00 15
```

GET_CARD_ID_SEND_CONF (0x3E)

Get the asynchronously card ID sending parameters.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything is OK, device answer with RSP packet and after that also the RSP_EXT packet of 9 bytes.
RSP_Val0 and RSP_Val1 are not in use.

1st byte of the RESPONSE_EXT contains send enable flag (bit 0), prefix enable flag (bit 1) and send removed enable flag (bit2).
2nd byte of the RESPONSE_EXT contains prefix character
3rd byte of the RESPONSE_EXT contains suffix character
array from 4th byte up to 7th byte of the RESPONSE_EXT contains baud rate value
8th byte of the RESPONSE_EXT contains internal CRC
9th byte of the RESPONSE_EXT contains checksum

Example:

```
CMD      55 3E AA 00 00 00 C8 (send CMD 3E, C8 checksum)

RSP      DE 3E ED 09 00 00 0B (RSP command 3E, 9 byte follows, 0B
checksum)

RSP_EXT  07 CC EE 80 25 00 00 87 0E (07 -bits 0,1,2 high, CC Prefix, EE
suffix,
                                     speed 9600 (0x2580),
                                     87 - checksum (
07,CC,EE,80,25,00,00),
                                     0E - checksum of RSP_EXT)
```

COMMANDS FOR WORKS WITH DESFIRE CARDS

DESFIRE_WRITE_AES_KEY (0x8E)

Command writes AES key into reader.

CMD_Par0 and CMD_Par1 are 0
1st byte of the CMD_EXT contains ordinal number of AES key into reader
array from 2nd byte up to 17th byte of the CMD_EXT contains AES key
18th byte of the CMD_EXT contains checksum

Device answer with RSP packet.

RSP_EXT
1st byte is 0
2nd byte is error code look at Appendix: ERROR CODES

3rd byte is checksum

Example:

AES key is `00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF`, and ordinal number is 3

```
CMD       55 8E AA 12 00 00 6A (send command 8E), 6A checksum
ACK       AC 8E CA 12 00 00 01 (ACK OK)
CMD_EXT   03 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF 0A
RSP       DE 8E ED 03 00 00 C5
RSP_EXT   00 00 07
```

GET_DESFIRE_UID (0x80)

Command returns Unique ID of card, if the Random ID is used.

CMD_Par0 and CMD_Par1 are 0
1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
array from 3rd to 18th byte of CMD_EXT contains AES key
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
22nd byte contains ordinal key number into application
23rd byte contains checksum

Response:
If no error, i.e. error code is CARD_OPERATION_OK, device answer with RSP packet and after that also the RSP_EXT packet of 12 bytes.
RSP_Val0 and RSP_Val1 are not in use.

array from 1st to 7th byte of RSP_EXT contains 7 bytes length card UID
8th and 9th bytes represents card's error code of operation (b9 * 256 + b8), look at Appendix: ERROR CODES for DESFire card operations

10th and 11th bytes represents execution time of command
12th byte is checksum.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command
3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents card's error code of operation (b2 * 256 + b1), look at Appendix: ERROR CODES for DESFire card operations

3rd and 4th bytes represents execution time of command
5th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00001, ordinal key number into application is 1.

```
CMD         55 80 AA 17 00 00 6F
(send command 80), 6F checksum
ACK         AC 80 CA 17 00 00 F8
(ACK OK)
CMD_EXT     01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 F0 01 F9
(internal key uses so AES key bytes may have any value (all 00), F9 checksum)

RSP         DE 80 ED 0C 00 00 AC
(RSP command 80, 12 bytes follows, 0B checksum)
RSP_EXT     04 01 02 03 05 06 07 B9 0B 0A 00 BF
(UID is 04010203050607, error code is 0BB9, execution time is 000A , checksum is BF)
```

DESFIRE_FREE_MEM (0x8D)

Command returns the available bytes on the card

The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.

If no error, i.e. error code is CARD_OPERATION_OK, device answer with RSP packet and after that also the RSP_EXT packet of 9 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1), look at Appendix: ERROR CODES for DESFire card operations
3rd and 4th bytes represents execution time of command
array from 5th to 8th of RSP_EXT contains quantity of available bytes on card
9th byte is checksum

Example:

```
CMD       55 8D AA 00 00 00 79
RSP       DE 8D ED 09 00 00 BE
RSP_EXT   B9 0B 0A 00 E8 03 00 00 5A
(error code 0BB9, execution time 000A,free mem 000003E8 i.e. 1000)
```

DESFIRE_FORMAT_CARD(0x8C)

Function releases all allocated user memory on the card. All applications will be deleted, also all files within those applications will be deleted. Only the card master key, and card master key settings will not be deleted. This operation requires authentication with the card master key.

CMD_Par0 and CMD_Par1 are 0
1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
array from 3rd to 18th byte of CMD_EXT contains AES key
19th byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command
3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
3rd and 4th bytes represents execution time of command
5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1

```
CMD       55 8C AA 13 00 00 67                 (send command 8C), 67
checksum
ACK       AC 8C CA 13 00 00 00                 (ACK OK)

CMD_EXT   01 01 00 00 00 00 00 00 00 00 00 00  (internal key uses so AES
key
          00 00 00 00 00 00 07                  bytes may have any value
(all
                                                00), 07 checksum)
RSP       DE 8C ED 05 00 00 C1            (RSP command 8C, 5 byte follows,
BD checksum)
RSP_EXT   B9 0B AC 0D 1A (error code 0BB9, execution time 0DAC)
```

DESFIRE_SET_CONFIGURATION(0x8B)

Function allows you to activate the Random ID option, and/or Format disable option.

If these options are activated, then they can not be returned to the factory setting (Random ID disabled, Format card enabled).

This operation requires authentication with the card master key.

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

19th byte is 1 if Random ID enabled or 0 if Random ID disabled

20th byte is 1 if format card disabled or 0 if format card enabled

21st byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, Random ID enabled, format card disabled

```
CMD       55 8B AA 15 00 00 68                  (send command 8B), 68
checksum
ACK       AC 8B CA 15 00 00 FF                  (ACK OK)

CMD_EXT   01 01 00 00 00 00 00 00 00 00 00 00   (internal key uses so AES
key
          00 00 00 00 00 00 01 00 08             bytes may have any value
(all
                                                 00), Random ID 01,
format card
                                                 00, 08 checksum)
RSP       DE 8B ED 05 00 00 C4                  (RSP command 8B, 5 byte
follows,
                                                 BD checksum)
RSP_EXT   B9 0B 1A 00 AF                  (error code 0BB9, execution time
001A)
```

DESFIRE_GET_KEY_CONFIG(0x87)

Function allows to get card master key and application master key configuration settings. In addition it returns the maximum number of keys which can be stored within selected application.

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte contains checksum.

If no error, i.e. error code is CARD_OPERATION_OK, device answer with RSP packet and after that also the RSP_EXT packet of 7 bytes.

RSP_Val0 and RSP_Val1 are not in use.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is key settings

6th byte is maximum number of keys within selected application.

7th byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 2, AID = 0xF00001

```
CMD       55 87 AA 16 00 00 75 (send command 87), 75 checksum
ACK       AC 87 CA 16 00 00 FE (ACK OK)

CMD_EXT   01 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 F0
CA(internal key uses so AES key bytes may have any value (all 00), CA
checksum)

RSP       DE 87 ED 07 00 00 BA          (RSP command 87, 7 bytes
follows, BA checksum)
RSP_EXT   B9 0B 1A 00 09 03 A9     (error code 0BB9, execution time
001A, key settings 9, maximum number of key 3)
```

DESFIRE_CHANGE_KEY_CONFIG(0x88)

Function allows to set card master key, and application master key configuration settings.

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is key settings

23rd byte contains checksum.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 2, AID = 0xF00001, key settings is 9

```
CMD       55 88 AA 17 00 00 67 (send command 88), 67 checksum
ACK       AC 88 CA 17 00 00 00 (ACK OK)

CMD_EXT   01 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 F0
09 02(internal key uses so AES key bytes may have any value (all 00), 02
checksum)

RSP       DE 88 ED 05 00 00 C6          (RSP command 88, 5 bytes
follows, C5 checksum)
RSP_EXT   B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_CHANGE_AES_KEY(0x86)

Function allow to change any AES key on the card. Changing the card master key require current card
master key authentication. Authentication for the application keys changing depend on the application master key settings (which key uses for authentication).

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT bit 0 set if uses internal AES key for authentication, bit 1 set if internal AES key uses as new key, bit 3 set if internal AES key uses as old key, high nibble is ordinal number of internal AES key which uses as old key, if they uses.

2nd byte of the CMD_EXT low nibble is ordinal number of internal AES key which uses for authentication or 0 if uses external AES key, high nibble is ordinal number of internal AES key which uses as new key of 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key for authentication

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is key number into application which uses for authentication

array from 23rd to 38th byte of CMD_EXT contains new AES key

38th byte is key number into application that will be changed

array from 39th to 54th byte of CMD_EXT contains new AES key

55th byte contains checksum.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Change the key number 2, into AID 0xF00001. Authentication with master application key key number 0.
Key for authentication is internal key number 1, new key is internal key number 2, and old key is internal key number 3.

```
CMD       55 86 AA 37 00 00 55 (send command 88, 0x37 bytes follows 55
checksum)
ACK       AC 86 CA 37 00 00 DE (ACK OK)

CMD_EXT   33 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 F0
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 E8(internal key uses so AES key bytes may
have any value (all 00), E8 checksum)

RSP       DE 86 ED 05 00 00 B7          (RSP command 86, 5 bytes
follows, C5 checksum)
RSP_EXT   B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_CREATE_APPLICATION(0x84)

Function allows to create new application on the card. Is the card master key authentication is required, depend on the card master key settings. Maximal number of applications on the card is 28. Each application is linked to set of up 14 different user definable access keys.

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is 1 if authentication required, or 0 if no need the authentication

23rd byte is application key settings

24th byte is maximal number of keys into application

25th contains checksum.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, AID = 0xF00002, key settings is 9, maximal number of application keys is 3, authentication required

```
CMD       55 84 AA 19 00 00 69 (send command 84), 69 checksum
ACK       AC 84 CA 19 00 00 02 (ACK OK)

CMD_EXT   01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
01 09 03 00 (internal key uses so AES key bytes may have any value (all
00), 00 checksum)

RSP       DE 84 ED 05 00 00 B9          (RSP command 84, 5 bytes
follows, B9 checksum)
RSP_EXT   B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_DELETE_APPLICATION(0x89)

Function allows to deactivate application on the card. AID allocation is removed, but deleted memory blocks can only recovered by using Format card function.

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte contains checksum

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, AID = 0xF00002

```
CMD       55 89 AA 16 00 00 67 (send command 89), 67 checksum
ACK       AC 89 CA 16 00 00 00 (ACK OK)

CMD_EXT   01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
F9 (internal key uses so AES key bytes may have any value (all 00), F9
checksum)

RSP       DE 89 ED 05 00 00 C6          (RSP command 89, 5 bytes
follows, C6 checksum)
RSP_EXT   B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_CREATE_STD_FILE(0x85)

Function allows to create file for the storage unformatted user data within existing application on the card. Maximal number of files into application is 32. The file will be created in the currently selected application. Is the application master key authentication is required, depend on the application master key settings.
Communication settings define communication mode between reader and card. The communication modes are:
- plain communication communication settings value is 0x00
- plain communication secured by MACing communication settings value is 0x01
- fully enciphered communication communication settings value is 0x11
Access rights for read, write, read&write and changing, references certain key within application's keys (0 – 13). If value is 14, this means free access, independent of previous authentication. If value is 15, this means deny access (for example if write access is 15 then the file type is read only).

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is ID of file that will be created (0 – 31)

23rd and 24th bytes represented access rights for read, write, read&write and changing

array from 25th to 28th of CMD_EXT contains file size in bytes

29th byte is 1 if authentication required, or 0 if no need the authentication

30th byte is communication settings

31st byte is checksum

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, AID = 0xF00002, authentication required, file ID is 1, communication settings is 0x11, access rights is 0x2110 (read with key 2, write with key 1, read&write with key 1, changing with key 0), file size is 1000 (0x000003E8)

```
CMD       55 85 AA 1F 00 00 67 (send command 89), 67 checksum
ACK       AC 85 CA 1F 00 00 00 (ACK OK)

CMD_EXT   01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
01 10 21 E8 03 00 00 01 11 40 (internal key uses so AES key bytes may
have any value (all 00), 40 checksum)

RSP       DE 85 ED 05 00 00 BA          (RSP command 85, 5 bytes
follows, BA checksum)
RSP_EXT   B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_DELETE_FILE(0x8A)

Function deactivates a file within currently selected application. Allocated memory blocks associated with deleted file not set free. Only format card function can delete the memory blocks. Is the application master key authentication is required, depend on the application master key settings.

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is ID of file that will be deleted (0 – 31)

23rd byte is 1 if authentication required, or 0 if no need the authentication

24th byte is checksum

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, AID = 0xF00002, authentication required, file ID is 1

```
CMD       55 8A AA 18 00 00 74 (send command 8A), 74 checksum
ACK       AC 8A CA 18 00 00 FB (ACK OK)

CMD_EXT   01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
01 01 F9 (internal key uses so AES key bytes may have any value (all
00), F9 checksum)

RSP       DE 8A ED 05 00 00 C3          (RSP command 8A, 5 bytes
follows, C3 checksum)
RSP_EXT   B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_READ_FROM_STD_FILE(0x83)

Function allow to read data from Standard Data File. Read command requires a preceding authentication either with the key specified for Read or Read&Write access.

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is application key number for reading

23rd byte is ID of file (0 – 31)

23rd byte is 1 if authentication required, or 0 if no need the authentication

24th and 25th bytes represents start position for read operation within file

26th and 27th bytes represents number of data to be read

28th byte is communication settings

29th byte is checksum

Reading the data is specific and is done in a loop. Reads one data, and if it is 0, then reads another that indicates how much data follows in the package. This is repeated until the required amount of data read. If the first data is different from 0, then reader will be sent standard response.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00002, authentication required, file ID is 1, reading key number is 2, bytes for read 50 from start address 10, communication settings 0x11

```
CMD       55 83 AA 1D 00 00 68 (send command 83), 68 checksum
ACK       AC 83 CA 1D 00 00 FB (ACK OK)

CMD_EXT   01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
02 01 01 0A 00 32 00 11 E2 (internal key uses so AES key bytes may have
any value (all 00), E2 checksum)

DATA      00 32 01 02 03 04 05 06 07 08 09 0A 01 02 03 04 05 06 07 08 09
0A 01 02 03 04 05 06 07 08 09 0A 01 02 03 04 05 06 07 08 09 0A 01 02 03
04 05 06 07 08 09 0A

RSP       DE 8A ED 05 00 00 C3          (RSP command 8A, 5 bytes
follows, C3 checksum)
RSP_EXT   B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_WRITE_TO_STD_FILE(0x82)

Function allow to write data to Standard Data File, or to Backup Data File. Write command requires a preceding authentication either with the key specified for Write or Read&Write access.

CMD_Par0 and CMD_Par1 are 0

1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key

2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key

array from 3rd to 18th byte of CMD_EXT contains AES key

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is application key number for writing

23rd byte is ID of file (0 – 31)

24th byte is 1 if authentication required, or 0 if no need the authentication

25th and 26th bytes represents start position for read operation within file

27th and 28th bytes represents number of data to be write

29th byte is communication settings

array from 30th to 30 + block size number of data for writing contains maximal 160 data for writing

31 + block size byte is checksum

If you want to enter more than 160 bytes, then it is done in blocks of up to 160 bytes. After the first block of data reader sent 0xAD if necessary to receive more data, or 0xDD if no need more data, or at any error. When you receive 0xAD then sends a packet in which the first byte indicates how many bytes follow. When you receive 0xDD then follow standard response.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

1st and 2nd bytes represents execution time of command

3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

3rd and 4th bytes represents execution time of command

5th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00002, authentication required, file ID is 1, writing key number is 1, bytes for write 50 from start address 10, communication settings 0x11

```
CMD       55 82 AA 51 00 00 33 (send command 82), 33 checksum
ACK       AC 82 CA 51 00 00 BC (ACK OK)

CMD_EXT   01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
01 01 01 0A 00 32 00 11 01 02 03 04 05 06 07 08 09 0A 01 02 03 04 05 06
07 08 09 0A 01 02 03 04 05 06 07 08 09 0A 01 02 03 04 05 06 07 08 09 0A
01 02 03 04 05 06 07 08 09 0A CRC (internal key uses so AES key bytes
may have any value (all 00), CRC checksum)

DATA      DD  (no need more data)

RSP       DE 82 ED 05 00 00 BB          (RSP command 82, 5 bytes
follows, BB checksum)
RSP_EXT   B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

COMMANDS FOR READER SETTINGS

SET_BAD_SELECT_NR_MAX(0x3F)

The function allows you to set the number of unsuccessful card selections before it can be considered that the card is not placed on the reader. Period between two card selections is approximately 10ms. Default value of this parameter is 20 i.e. 200ms. This parameter can be set in the range of 0 to 254.
The CMD_EXT set is not in use.
CMD_Par0 is bad select card number maximal
CMD_Par1 = (CMD_Par0 xor A3) + 7
The RSP_EXT is not in use

Example:

Bad select card maximal is 10
CMD_Par0 = 0x0A, CMD_Par1 = (0A xor A3) + 7 = B0

```
CMD       55 3F AA 00 0A B0 81 (send command 3F), 81 checksum
RSP       DE 3F ED 00 00 00 13
```

GET_BAD_SELECT_NR_MAX(0x44)

The function returns value of maximal unsuccessful card selections, which is set in reader.

The CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are 0
RSP_EXT - 1st byte is maximal value of bad select card number

Example:

```
CMD       55 44 AA 00 00 00 C2 (send command 44), C2 checksum
RSP       DE 44 ED 02 00 00 7C
RSP_EXT   0A 11              (number is 0x0A)
```

FUNCTIONS FOR THE READER LOW POWER MODE CONTROL

ENTER_SLEEP_MODE (0x46)

Function allows the low power reader mode. Reader is in sleep mode. RF field is turned off. The reader is waiting for the command to return to normal working mode.
The CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are 0
The RSP_EXT is not in use.

Example:

```
CMD       55 46 AA 00 00 00 C0 (send command 46), C0 checksum
RSP       DE 46 ED 00 00 00 7C
```

LEAVE_SLEEP_MODE (0x47)

Function allows return from low power reader mode to normal working mode.

The CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are 0
The RSP_EXT is not in use.

Example:

```
WAKE UP BYTE   00   (send just before command)
CMD       55 47 AA 00 00 00 BF (send command 47), BF checksum
RSP       DE 47 ED 00 00 00 7B
```

AUTO_SLEEP_SET (0x4D)

supported from firmware version 3.8.18

Command description:

This function permanently set auto-sleep functionality of the device. Valid value for the CMD_Par0 range is from 1 to 254 seconds. To permanently disable auto-sleep functionality use 0 or 0xFF for the CMD_Par0 value.
The CMD_EXT is not in use.
CMD_Par1 are 0 (not in use).
The RSP_EXT is not in use.

AUTO_SLEEP_GET (0x4E)

supported from firmware version 3.8.18

Command description:

This command returns permanently configured auto-sleep wait seconds.
The CMD_EXT is not in use.
CMD_Par0 and CMD_Par1 are 0 (not in use).
The RSP_EXT is not in use.
RSP_Val0 containing configured auto-sleep wait seconds.
RSP_Val1 is 0 (not in use).

Commands for Reader NTAG Emulation Mode

WRITE_EMULATION_NDEF (0x4A)

supported from firmware version 3.8.0

Command description:

Command store a message record for NTAG emulation mode in to the reader. The CMD_EXT is used and contains NDEF message for tag emulation mode.

> 1st and 2nd byte of the CMD_EXT set contains length of the following NDEF message (parameter called ndef_len).
> next ndef_len bytes contains NDEF message.
> last byte of the CMD_EXT set contains checksum

Example:

(NDEF message is URI type with “www.d-logic.net” payload):

```
CMD        55 4A AA 16 00 00 AA
ACK        AC 4A CA 16 00 00 41
CMD_EXT    14 00 03 10 D1 01 0C 55 01 64 2D 6C 6F 67 69 63 2E 6E 65 74 FE
0E
RSP        DE 4A ED 00 00 00 80
```

Possible error codes:

```
        WRITE_VERIFICATION_ERROR = 0x70
        MAX_SIZE_EXCEEDED = 0x10
```

TAG_EMULATION_START (0x48)

supported from firmware version 3.8.0

Put the reader permanently in a NDEF tag emulation mode. Only way for a reader to exit from this mode is to receive the TAG_EMULATION_STOP command.
In this mode, the reader can only answer to the following commands:

```
WRITE_EMULATION_NDEF (0x4A)
TAG_EMULATION_STOP (0x49)
TAG_EMULATION_START (0x48)
GET_READER_TYPE (0x10)
GET_READER_SERIAL (0x11)
GET_FIRMWARE_VERSION (0x29)
GET_HARDWARE_VERSION (0x2A)
GET_BUILD_NUMBER (0x2B)
GET_SERIAL_NUMBER (0x40)
```

Issuing another commands in this mode, results with the following error code:

```
        FORBIDDEN_IN_TAG_EMULATION_MODE = 0x90
```

Possible error codes:

```
        WRITE_VERIFICATION_ERROR = 0x70
```

(command resulting in a direct write to a device non-volatile memory)

Example:

```
CMD        55 48 AA 00 00 00 BE
RSP        DE 48 ED 00 00 00 82
```

TAG_EMULATION_STOP (0x49)

supported from firmware version 3.8.0

Allows the reader permanent exit from a NDEF tag emulation mode.

Possible error codes:

```
        WRITE_VERIFICATION_ERROR = 0x70
```

(command resulting in a direct write to a device non-volatile memory)

Example:

```
CMD         55 49 AA 00 00 00 BD
RSP         DE 49 ED 00 00 00 81
```

Ad-Hoc emulation mode:

This mode enables user controlled emulation from the user application. There is “nfc-rfid-reader-sdk/ufr-examples-ad_hoc_emulation-c” console example written in C, using our uFCoder library (see uFR API). This example demonstrate usage of the uFCoder library functions that implement sending of the following commands:

AD_HOC_EMULATION_START (0x76)

supported from firmware version 3.9.34

Put uFR in emulation mode with ad-hoc emulation parameters (see. SET_AD_HOC_EMULATION_PARAMS and GET_AD_HOC_EMULATION_PARAMS). uFR stays in emulation mode until AD_HOC_EMULATION_STOP command is sent or reader reset.

The CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are not in use.
The RSP_EXT is not in use

Example:

```
CMD         55 76 AA 00 AA CC F6
RSP         DE 76 ED 00 00 00 4C
```

AD_HOC_EMULATION_STOP (0x77)

supported from firmware version 3.9.34

Terminate uFR ad-hoc emulation mode.

The CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are not in use.
The RSP_EXT is not in use

Example:

```
CMD        55 77 AA 00 AA CC F5
RSP        DE 77 ED 00 00 00 4B
```

GET_EXTERNAL_FIELD_STATE (0x9F)

supported from firmware version 3.9.34

This command returns external field state when uFR is in ad-hoc emulation mode.

The CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are not in use.
RSP_Val0 is 0 if external field isn't present or 1 if field is present.
RSP_Val1 is not in use.
The RSP_EXT is not in use

Example:

```
CMD        55 9F AA 00 AA CC 0D
RSP        DE 9F ED 00 01 00 B4
```

GET_AD_HOC_EMULATION_PARAMS (0x9D)

supported from firmware version 3.9.35

This command returns current ad-hoc emulation parameters. On uFR power on or reset ad-hoc emulation parameters are set back to their default values.

The CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are not in use.
RSP_Val0 contains current ad-hoc threshold parameters. Default value is 0xF7.
RSP_Val1 contains current ad-hoc receiver gain and RF level values of the RFCfgReg register (most significant bit of this value should be 0 all the time). Default value is 0x79.
The RSP_EXT is not in use

Example:

```
CMD        55 9D AA 00 AA CC 0B
RSP        DE 9D ED 00 F7 79 27
```

SET_AD_HOC_EMULATION_PARAMS (0x9E)

supported from firmware version 3.9.35

This command set ad-hoc emulation parameters. On uFR power on or reset ad-hoc emulation parameters are set back to their default values.

The CMD_EXT set is not in use.
CMD_Par0 contains current ad-hoc threshold parameters. Default value is 0xF7.
CMD_Par1 contains current ad-hoc receiver gain and RF level values of the RFCfgReg register (most significant bit of this value should be 0 all the time). Default value is 0x79.

Example:

```
CMD       55 9E AA 00 F7 79 F6
RSP       DE 9E ED 00 00 00 B4
```

SET_SPEED_PERMANENTLY (0x4B)

supported from firmware version 3.8.4

Permanently set the requested transceive data rates between reader and ISO14443 – 4A card / tag.

CMD_EXT set not in use.

CMD_Par0 containing requested transmit speed constant

CMD_Par1 containing requested receive speed constant

The RSP_EXT not in use.

Valid speed constants are:

Const	***Requested speed***
0	106 kbps (default)
1	212 kbps
2	424 kbps

Possible error codes:

`WRITE_VERIFICATION_ERROR = 0x70`

(command resulting in a direct write to a device non-volatile memory)

Example:

```
CMD       55 4B AA 00 02 02 BB
RSP       DE 4B ED 00 00 00 7F
```

GET_SPEED_PARAMETERS (0x4C)

supported from firmware version 3.8.4

This command returns permanently configured transceive data rates between reader and ISO14443 – 4A card / tag.

CMD_EXT set not in use.
The RSP_EXT not in use.
    RSP_Val0 containing configured transmit speed constants
    RSP_Val1 containing configured receive speed constants

Valid speed constants are:

Const	*Configured speed*
0	106 kbps (default)
1	212 kbps
2	424 kbps

Example:

```
CMD         55 4C AA 00 00 00 BA
RSP         DE 4C ED 00 02 02 86
```

Support for ISO 14443-4A protocol commands

Basic commands

SET_ISO14433_4_MODE (0x93)

supported from firmware version 3.9.36

After issuing this command, ISO 14443-4A tag in a field will be selected and RF field polling will be stopped. Furthermore all the others ISO 14443-4A protocol commands can be issued in a sequence (including APDU_TRANSCEIVE). Last command in those sequences should be S_BLOCK_DESELECT.

Example:

```
CMD       55 93 AA 00 AA CC 11
RSP       DE 93 ED 00 00 00 A7
```

I_BLOCK_TRANSCEIVE (0x90)

supported from firmware version 3.9.36

Used to convey information for use by the application layer.
CMD_Par0 contains command specific flags (0x0C additional chained i block , 0x04 single i block)
CMD_Par1 containing timeout value in [ms]
CMD_EXT contains i-block body.
RSP_EXT contains i-block response.

R_BLOCK_TRANSCEIVE (0x91)

supported from firmware version 3.9.36

Used to convey positive or negative acknowledgements. An R-block never contains an INF field. The acknowledgement relates to the last received block.
CMD_Par0 contains acknowledge flag (1 = ACK, 0 = NOT ACK)
CMD_Par1 containing timeout value in [ms]

CMD_EXT not in use.
RSP_EXT contains i-block response.

S_BLOCK_DESELECT (0x92)

supported from firmware version 3.9.36

Issue this command to deselect tag and restore RF field polling. This command is mandatory at the end of any
ISO 14443-4A protocol command sequence.

Example:

```
CMD       55 92 AA 00 64 00 10
RSP       DE 92 ED 00 00 00 A8
```

Support for APDU commands in ISO 14443-4A tags

APDU_TRANSCEIVE (0x94)

supported from firmware version 3.9.39

Some ISO 14443-4A tags supports the APDU message structure according to ISO/IEC 7816-4. For more details you have to check the manual for the tags that you planning to use.
Issuing APDU_TRANSCEIVE command you will send C-APDU to ISO 14443-4A tag selected using SET_ISO14433_4_MODE. After successfully executed APDU_TRANSCEIVE command uFR returns byte array which contains R-APDU including data field (body) following by the trailer (SW1 and SW2 APDU status bytes).

CMD_Par0 not in use
CMD_Par1 containing timeout value in [ms]
CMD_EXT contains C-APDU (i.e. {CLA, INS, P0, P1, Lc, … Nc bytes … , Le})
RSP_EXT contains R-APDU including data field (body) following by the trailer (SW1 and SW2 APDU status bytes).

Example:

Issuing NDEF Tag Application Select command: 00 A4 04 00 07 D2 76 00 00 85 01 01 00

```
CMD       55 94 AA 0E 00 CC B0
ACK       AC 94 CA 0E 00 CC 37
CMD_EXT   00 A4 04 00 07 D2 76 00 00 85 01 01 00 8D
RSP       DE 94 ED 03 00 00 AB
RSP_EXT   90 00 97
```

PKI infrastructure and digital signature support

Fully supported from firmware version 3.9.55

In our product range, we have special cards called “D-Logic JCApp” (working title), which contains support for PKI infrastructure and digital signing. To use these features you have to implement specific APDU command sequences using APDU_TRANSCEIVE command described before. We have PKI infrastructure and digital signature support implemented in our API (for reference read “**uFR Series NFC reader’s API**”).

Appendix: ERROR CODES

ERROR	VALUE
OK	0x00
COMMUNICATION_ERROR	0x01
CHKSUM_ERROR	0x02
READING_ERROR	0x03
WRITING_ERROR	0x04
BUFFER_OVERFLOW	0x05
MAX_ADDRESS_EXCEEDED	0x06
MAX_KEY_INDEX_EXCEEDED	0x07
NO_CARD	0x08
COMMAND_NOT_SUPPORTED	0x09
FORBIDEN_DIRECT_WRITE_IN_SECTOR_TRAILER	0x0A
ADDRESSED_BLOCK_IS_NOT_SECTOR_TRAILER	0x0B
WRONG_ADDRESS_MODE	0x0C
WRONG_ACCESS_BITS_VALUES	0x0D
AUTH_ERROR	0x0E
PARAMETERS_ERROR	0x0F
MAX_SIZE_EXCEEDED	0x10
UNSUPPORTED_CARD_TYPE	0x11
COUNTER_ERROR	0x12
WRITE_VERIFICATION_ERROR	0x70
BUFFER_SIZE_EXCEEDED	0x71
VALUE_BLOCK_INVALID	0x72
VALUE_BLOCK_ADDR_INVALID	0x73
VALUE_BLOCK_MANIPULATION_ERROR	0x74
WRONG_UI_MODE	0x75
KEYS_LOCKED	0x76
KEYS_UNLOCKED	0x77
WRONG_PASSWORD	0x78

CAN_NOT_LOCK_DEVICE	0x79
CAN_NOT_UNLOCK_DEVICE	0x7A
DEVICE_EEPROM_BUSY	0x7B
RTC_SET_ERROR	0x7C
EEPROM_ERROR	0x7D
NO_CARDS_ENUMERRATED	0x7E
CARD_ALREADY_SELECTED	0x7F
WRONG_CARD_TYPE	0x80
AIS_FOREIGN_CARD	0x81
AIS_WRONG_FORMAT_CARD	0x82
FORBIDDEN_IN_TAG_EMULATION_MODE	0x90

Appendix: ERROR CODES for DESFire card operations

```
#define DATA_OVERFLOW                  2990
#define READER_ERROR                   2999
#define NO_CARD_DETECTED         3000
#define CARD_OPERATION_OK              3001
#define WRONG_KEY_TYPE                 3002
#define KEY_AUTH_ERROR                 3003
#define CARD_CRYPTO_ERROR              3004
#define READER_CARD_COMM_ERROR 3005
#define PC_READER_COMM_ERROR           3006


/* Status and error codes */

#define OPERATION_OK             0x0C00
#define NO_CHANGES               0x0C0C
#define OUT_OF_EEPROM_ERROR      0x0C0E
#define ILLEGAL_COMMAND_CODE     0x0C1C
#define INTEGRITY_ERROR          0x0C1E
#define NO_SUCH_KEY              0x0C40
#define LENGTH_ERROR             0x0C7E
#define PERMISSION_DENIED        0x0C9D
#define PARAMETER_ERROR          0x0C9E
#define APPLICATION_NOT_FOUND    0x0CA0
#define APPL_INTEGRITY_ERROR     0x0CA1
#define AUTHENTICATION_ERROR     0x0CAE
#define ADDITIONAL_FRAME         0x0CAF
#define BOUNDARY_ERROR           0x0CBE
```

```
#define PICC_INTEGRITY_ERROR    0x0CC1
#define COMMAND_ABORTED         0x0CCA
#define PICC_DISABLED_ERROR     0x0CCD
#define COUNT_ERROR             0x0CCE
#define DUPLICATE_ERROR         0x0CDE
#define EEPROM_ERROR_DES        0x0CEE
#define FILE_NOT_FOUND          0x0CF0
#define FILE_INTEGRITY_ERROR    0x0CF1
```

Change log:

Date	Description	Document revision	refers to the firmware ver.
2018-05-30	DESFIRE_WRITE_AES_KEY, and GET_DESFIRE_UID examples are corrected	1.1	
2018-05-30	Appendix: ERROR CODES for DESFire card operations	1.1	
2018-05-29	PKI infrastructure and digital signature support	1.1	3.9.55
2018-05-29	Changed date format in a Change log. Now we use more universal ‘yyyy-mm-dd’ date format.	1.1	-
2017-06-29	Support for APDU commands in ISO 14443-4A tags	1.0	3.9.39
2017-05-23	Support for ISO 14443-4A protocol commands	1.0	3.9.36
2017-05-03	Commands for a Ad-Hoc emulation mode parameters manipulation. (GET_AD_HOC_EMULATION_PARAMS and SET_AD_HOC_EMULATION_PARAMS).	1.0	3.9.35
2017-05-03	Ad-Hoc emulation mode commands.	1.0	3.9.34
2016-08-06	FAST_READ ISO14443-3 command with LINEAR_READ utilisation.	1.0	3.9.14
2016-06-06	Title “Authentication mode considerations” changed to “Authentication mode considerations for Mifare Classic tags”	1.0	
2016-06-06	New Title “Authentication mode considerations for NTAG 21x and other T2T tags”	1.0	3.9.10